

New models of sustainable mobility in Smart Cities

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Abstract

The aim of this study is to explore new models of sustainable mobility in smart cities, with a particular focus on the intersection between digitalisation, social inclusion and sustainable urban planning. Through an interdisciplinary analysis combining bibliographic review and international case studies (Barcelona, Singapore, Milan, Amsterdam, Oslo and Tokyo), the work highlights how urban mobility is now at the heart of a technological and cultural transformation. The adoption of advanced digital systems, such as artificial intelligence and Mobility-as-a-Service, not only improves efficiency and reduces environmental impact, but also contributes to redefining social relations and urban governance models. However, critical issues related to digital inequalities, trust in institutions and civic participation are emerging. The paper proposes a multidimensional approach based on the triple bottom line theory, which integrates environmental sustainability, social equity and economic development. Therefore, inclusive and participatory policies become fundamental to ensuring that sustainable mobility becomes a common good capable of promoting more resilient, accessible and fair cities.

Keywords: Sustainability; Smart Cities; Social Inclusion

Introduction

Sustainable mobility is now one of the cornerstones of smart city development. In a context of increasing urbanisation, population growth and pressure on urban ecosystems, it represents a strategic and multidimensional response to contemporary challenges, providing environmentally friendly, accessible and technologically advanced transport solutions (Geels, 2012). To be truly sustainable, the cities of the future cannot do without a mobility system capable of reducing environmental impact, improving accessibility for all citizens and promoting forms of social inclusion and territorial cohesion. The concept of sustainability, as defined by the Brundtland Report (World Commission on Environment and Development [WCED], 1987), implies the ability to

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meet the needs of the present without compromising those of future generations. Applied to the context of urban mobility, this means ensuring solutions that are durable, economically advantageous, socially equitable and environmentally sustainable. Sustainability has three fundamental dimensions: environmental, social and economic (Harvey, 1989). Ideally, any intervention in the transport sector should take this triple balance into account. On the environmental front, sustainable mobility aims to reduce air and noise pollution, limit greenhouse gas emissions and promote the use of renewable energy sources (Banister, 2008). The gradual phasing out of private internal combustion vehicles in favour of electric vehicles, the upgrading of public transport and the creation of cycling and walking infrastructure are effective strategies for mitigating the environmental impact of transport (Litman, 2021). The social dimension of sustainable mobility, on the other hand, emphasises inclusiveness and accessibility. It is essential to ensure that all citizens, regardless of age, gender, socio-economic status or disability, have access to efficient and safe transport services. Territorial inequalities and physical or economic barriers that limit the mobility of certain groups must be addressed with targeted policies (Lucas, 2012), such as reduced fares, accessible infrastructure and on-demand services for peripheral areas. The economic aspect concerns the financial sustainability of the proposed solutions. Investment and maintenance costs must be balanced against economic and social benefits, also considering the impacts on public health and urban competitiveness (Dodson & Sipe, 2008). Cities that invest in sustainable mobility tend to become more attractive to citizens, businesses and tourists, contributing to economic growth and urban regeneration. In addition to these aspects, sustainable mobility plays a key role in building more resilient cities. Urban resilience is the ability of a city to withstand, adapt and thrive in the face of shocks and stresses, whether climatic, economic or social (Ahern, 2011). Flexible and intermodal transport systems are essential to ensure the safety and continuity of services, especially in emergency situations such as extreme weather events or pandemics. The integration of digital technologies into mobility systems enables constant traffic monitoring, more efficient fleet management and route optimisation thanks to real-time data (Sassen, 2012; Shaheen & Cohen, 2013). Intelligent transport systems (ITS) use sensors, algorithms and digital platforms to improve road safety, reduce travel times and minimise energy consumption (Gonzalez et al., 2008). Artificial intelligence and machine learning are emerging as crucial tools for predictive modelling of transport demand. By analysing big data generated by mobile devices and connected vehicles, administrations can gain a systemic view of urban dynamics, optimise resources and improve urban planning (Batty, 2013). A further element is shared mobility (car sharing, bike sharing, ride hailing). These services reduce dependence on private cars, improve the efficiency of the transport system and promote the rational use of urban resources (Shaheen, Guzman, & Zhang, 2010). However, to function at their best, they require effective integration with public transport and consistent regulation by local authorities. The role of public policy is therefore

essential. Institutions must define clear strategies, incentivise sustainable behaviour and invest in inclusive infrastructure. It is equally important to actively involve citizens in decision-making processes, thereby strengthening the legitimacy and effectiveness of the policies adopted (Healey, 1997). Finally, promoting a culture of sustainable mobility also means educating citizens to take a more conscious and collective view of the city. Awareness campaigns, environmental education and civic engagement are key tools for fostering change in behaviour and values related to mobility (Banister, 2008). In conclusion, sustainable mobility goes far beyond logistical efficiency: it is a catalyst for social cohesion, urban innovation and environmental justice. Cities that recognise its potential will be better equipped to face the challenges of the future, putting people, the environment and the quality of urban life at the centre.

History and context of sustainable mobility

The history of sustainable mobility is deeply intertwined with the evolution of human society, transport technologies and environmental awareness. Understanding how the concept of sustainable mobility has developed involves analysing changes in modes of transport, the environmental problems that have emerged with industrialisation and the political and social responses that have followed. In a global context marked by climate challenges, increasing urbanisation and energy crises, sustainable mobility is now a fundamental pillar for the future of our cities. Throughout history, humans have sought increasingly efficient ways to move around. In pre-industrial societies, mobility was severely limited by human or animal physical means and, as a result, had minimal environmental impact. The use of animal power, sailing boats and, later, carriages were forms of mobility with a low environmental impact. Pre-modern cities were compact and walkable, organised according to a logic of proximity that favoured travel on foot or by simple means. With the onset of the industrial revolution in the 18th century, transport underwent a radical transformation. The introduction of the steam engine revolutionised rail and maritime transport, reducing travel times but exponentially increasing environmental impact. Industrialisation led to the concentration of productive activities and the emergence of large urban agglomerations, changing the way people lived and travelled. According to Pomeranz (2000), the industrial revolution marked an irreversible break in the relationship between humans, energy and the environment.

The 20th century saw the emergence of the car as the predominant means of transport, especially in Western countries. The Fordist model of production and mass motorisation led to the widespread use of private cars. The United States was a pioneer in this process: cities such as Los Angeles were designed to be travelled almost exclusively by car. In Europe, post-war reconstruction encouraged a similar spread, albeit at different times and in different ways. Motorways, ring roads and car parks became central features of urban planning. However, this model had dramatic environmental, social and health consequences: air pollution, noise pollution, increased road accidents

and oil dependency became increasingly evident problems. As Banister and Marshall (2000) note, 'the dominance of the car has shaped our cities in ways that make them less liveable, less safe and less equitable'. As Banister and Marshall (2000) note, 'the dominance of the car has shaped our cities in ways that make them less liveable, less safe and less equitable'. At the same time, problems related to urban congestion increased, leading to significant economic losses. A study by the European Commission (2014) estimated that traffic congestion costs around 1% of European GDP.

In the 1960s and 1970s, environmental movements began to emphasise the negative impacts of car traffic. The Club of Rome's report, 'The Limits to Growth' (1972), was one of the first documents to question the sustainability of the development model based on unlimited growth, including the transport sector. At the same time, cities such as Copenhagen and Amsterdam began to promote policies for cycling and public transport. In Italy, Law 285 of 1977 introduced urban mobility planning as a specific area of spatial planning for the first time. However, it was not until the 1990s that the concept of sustainable mobility began to take concrete shape in European and international political agendas. As Bertolini and Le Clercq (2003) state, 'a sustainable transformation of cities requires an integrated vision of urban development and transport'.

The concept of sustainable mobility was definitively established at the 1992 Earth Summit in Rio de Janeiro, where sustainability was recognised as a guiding principle of global development. The definition provided by the Brundtland Commission in 1987 — 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' — was also applied to transport systems. In 1998, the European Union published the White Paper 'European transport policy for 2010: time to decide', which pointed to the need to decouple economic growth from the growth in motorised traffic. This document laid the foundations for a new vision of mobility, focused on energy efficiency, emissions reduction and social equity. The European Commission (2001) defines sustainable mobility as 'the ability of people and goods to move freely, communicate, trade and establish relationships without compromising other human or ecological values, either now or in the future'.

With the start of the new millennium, the concept of sustainable mobility has been enriched by technological innovation. The term 'smart mobility' has come to refer to the use of digital technologies to improve the efficiency and sustainability of transport. Intelligent transport systems (ITS), car-sharing and bike-sharing applications, electric mobility and intermodality have become key tools for the transition to a more sustainable mobility system. The European urban agenda and programmes such as Horizon 2020 have promoted pilot projects for smart cities, in which sustainable mobility is an essential component. Cities are thus being rethought as resilient and accessible spaces where citizens can move around efficiently, safely and with low impact. According to Geels et al. (2012), the transition to sustainable mobility is a complex socio-technical

process that requires not only technological innovations but also changes in individual behaviour, cultural norms and institutional structures. In this regard, education on sustainable mobility and citizen involvement are fundamental tools.

Today, sustainable mobility is recognised as a priority in urban and environmental development policies. The Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda include specific targets for mobility (in particular Goal 11.2), which aims to ensure 'access to safe, affordable, accessible and sustainable transport systems for all'. However, the road to fully sustainable mobility is still long. Key challenges include cultural resistance to giving up private cars, territorial inequalities in access to public transport, financing sustainable infrastructure and integration between different levels of government and planning. Mobility is also increasingly influenced by global dynamics such as the climate crisis, energy transitions and migration flows. In the post-pandemic context, sustainable mobility takes on a new centrality. Covid-19 has reduced demand for mobility in some areas and strengthened interest in alternative modes such as cycling, active mobility and remote working. As Sheller (2021) states, the pandemic has acted as a catalyst for the reconfiguration of urban spaces, opening up new possibilities for more equitable and sustainable mobility.

Some international examples

- Barcelona: the 'Superblocks' model

Barcelona has introduced the 'superblocks' model, urban areas where vehicle traffic is restricted and public spaces are reserved for pedestrians and cyclists (Ajuntament de Barcelona, 2020). This model has improved air quality and encouraged socialisation in urban spaces.

The 'Superilles' model is not only an experiment in urban reorganisation, but also an attempt to respond to the challenges of modernity in a sustainable way. According to Beck (Beck, 1992), contemporary societies face global risks such as climate change, and local solutions such as 'Superilles' can mitigate these challenges through environmental and social sustainability. At the same time, Lefebvre emphasises that urban space is a social product and that its reconfiguration can influence the daily lives of citizens, promoting social capital and a sense of community (Lefebvre, 1991). From this perspective, the pedestrianisation of certain urban areas is not only an ecological advantage but also an opportunity to rethink the relationship between people and the urban environment, promoting a more inclusive and participatory model. The concept of 'superblocks' can be seen not only as an urban innovation but also as an opportunity to strengthen social cohesion. The possibility of reclaiming urban space and encouraging interaction between citizens recalls the concept of social capital, which according to Bourdieu plays a crucial role in collective well-being (Bourdieu, 1986). Greater pedestrian accessibility allows for the creation of new places for meeting and exchange, reducing

social isolation and improving the sense of belonging to the community. At the same time, the quality of public spaces influences the level of trust and civic participation, as highlighted by Putnam (Putnam, 2000). A well-designed urban environment can facilitate collaboration between citizens and institutions, promoting more participatory and inclusive governance dynamics. These aspects highlight how interventions in mobility and urban planning can have broader implications, contributing to the creation of more resilient cities geared towards collective well-being. Finally, Sassen's analysis of global cities offers interesting insights into how interventions such as 'superblocks' can be adapted to different urban contexts (Sassen, 2012). The success of these models depends not only on physical infrastructure, but also on the city's ability to harmoniously integrate technological innovation and social sustainability. The replicability of these solutions requires careful assessment of territorial and cultural specificities in order to promote a balance between urban development and citizens' quality of life.

- **Singapore: digitisation and big data for public transport**

Singapore uses data analysis to optimise traffic flows and improve public transport accessibility. The implementation of intelligent transport systems (LTA Singapore, 2021) has reduced travel times and CO2 emissions. The integration of digital technologies into urban mobility can be interpreted as part of a broader process of social transformation. According to Castells (Castells, 1996), cities are increasingly influenced by information and communication networks, and the efficiency of public transport becomes a lever for improving the quality of urban life. It should be added that the digitisation of transport in Singapore can be seen as an example of what Sassen calls 'global cities', where technological infrastructure is an essential element for competitiveness and economic sustainability (Sassen, 2012). The automation of traffic flows and the use of real-time data make it possible to adapt services to the emerging needs of the population, creating a more inclusive and efficient transport system. The adoption of these technologies represents a transformative process that goes beyond the purely infrastructural aspect. According to Castells, the information and communication network becomes the hub of urban organisation, dynamically connecting citizens, institutions and businesses. This leads to a redefinition of the concepts of accessibility and mobility, where the transport system's ability to adapt to changing needs becomes a priority (Castells, 1996). From Beck's perspective of reflexive modernisation, the introduction of digital solutions in transport represents an attempt to mitigate the risks arising from accelerated urbanisation, pollution and inefficient resource management (Beck, 1992). Contemporary societies seek to transform challenges into opportunities by developing resilient infrastructures capable of responding to environmental and social crises. In this sense, Lefebvre also emphasises that the production of urban space is not only the result of political and technological decisions, but also of social practices and interaction dynamics (Lefebvre, 1991). The digitisation of transport in Singapore is therefore not just a technical phenomenon, but also

affects the perception of public space, quality of life and citizen participation in urban dynamics. An efficient and technologically advanced transport system can influence collective behaviour and contribute to the construction of a more sustainable and inclusive urban model. This transformation also ties in well with Beck's concepts of reflexive modernisation, according to which societies seek to address contemporary risks through innovations that reduce environmental impact and optimise resources (Beck, 1992). The adoption of ITS is not just a technological choice, but reflects a broader strategy of rethinking the role of mobility in the cities of the future. In this sense, the introduction of advanced technological solutions is not limited to traffic management, but more broadly involves the way people live and interact in urban spaces. According to Castells, digital networks are transforming cities into interconnected environments where the flow of information becomes crucial for quality of life and urban planning (Castells, 1996). This interconnection not only improves mobility, but also redefines the relationships between administrations, citizens and businesses, promoting a more flexible model of governance that is adaptable to emerging needs. Furthermore, Lefebvre emphasises how the production of urban space is influenced by social practices and economic dynamics (Lefebvre, 1991). The digitalisation of mobility can therefore be seen not only as a response to the need to reduce environmental impact, but also as an opportunity to rethink the very structure of the city, promoting new models of accessibility and social inclusion. The ability to integrate different levels of mobility – from public transport to micro-mobility services – thus becomes a key element in ensuring more liveable, sustainable and resilient cities.

- **Milan: Green Mobility Policies**

Milan has introduced restricted traffic zones and incentives for electric mobility, reducing PM10 emissions in the city centre by 40%. In addition, the city has developed bike-sharing and car-sharing schemes to promote multimodal transport (Municipality of Milan, 2023; Maggi, 2020). As Maggi (Buehler, Pucher & Bauman, 2020) points out, reducing urban pollution and promoting soft mobility are essential strategies for improving the quality of life in cities, making urban spaces more accessible and liveable. The introduction of these measures can be analysed through Beck's theory of reflexive modernisation, according to which societies must continually adapt to emerging risks through innovative policies (Beck, 1992). Traffic restriction and the promotion of more sustainable means of transport are a strategy for addressing contemporary environmental challenges and reducing the impact of mobility on urban living conditions. At the same time, according to Castells, contemporary cities are characterised by networks connecting citizens and infrastructure, where the use of digital mobility solutions plays a crucial role in the transformation of urban space (Castells, 1996). The integration of bike sharing and car sharing not only helps reduce emissions, but also creates new ways for users to interact with the city, encouraging

flexible and accessible mobility patterns. From the perspective of Lefebvre's social space theory, the adoption of multimodal mobility is not just an infrastructural issue, but transforms the way people live and perceive urban space (Lefebvre, 1991). Access to more sustainable transport solutions contributes to the democratisation of the city, enabling greater participation and shared use of public spaces. Putnam's perspective on social capital emphasises how creating more liveable and accessible spaces can strengthen community ties and encourage greater social interaction (Putnam, 2000). This view highlights the importance of urban environments designed to foster inclusion and collective well-being, strengthening trust among citizens and promoting more active public participation. The transformation of mobility in Milan not only improves air quality and reduces traffic, but also contributes to building a more inclusive and cohesive urban environment. This evolution goes beyond environmental and logistical benefits, influencing the social dimension by promoting forms of sustainable mobility that facilitate interaction and dialogue between people. A more efficient and accessible transport system thus becomes a key element in strengthening social capital, enabling stronger connections between citizens and making the city a more liveable, equitable and dynamic place.

- **Amsterdam: Advanced Cycling Mobility**

Amsterdam is a global model for cycling mobility, with 48% of urban journeys made by bicycle. The government's ongoing investment in safe cycle lanes, dedicated parking facilities and incentives to use bicycles as the main mode of transport has helped to create a sustainable and efficient mobility system. The Bike First policy has enabled the city to keep CO₂ emissions low and maintain a high standard of living (De Gennaro, Paffumi, Martini, Giallonardo, Pedroso & Loiseau-Lapointe, 2020). However, the growing demand for bicycle space and the regulation of shared mobility traffic pose new challenges. From a theoretical perspective, Amsterdam's cycling mobility can be interpreted through the lens of Beck's reflexive modernisation, which emphasises that cities must adapt to environmental risks through innovative and sustainable solutions (Beck, 1992). Investing in cycling infrastructure is not only an ecological choice, but an attempt to rethink the entire urban framework to address contemporary challenges. Lefebvre emphasises that urban space is a social product and that its transformation can influence everyday life and social dynamics (Lefebvre, 1991). The expansion of cycling infrastructure and the reduction of car traffic promote a more inclusive and participatory urban environment, in which public space is reclaimed by citizens. Furthermore, Putnam's concept of social capital suggests that a bicycle-friendly city can strengthen community ties by encouraging more frequent and spontaneous social interactions (Putnam, 2000). Sassen offers another perspective, suggesting that successful global cities must integrate innovation and sustainability to remain competitive (Sassen, 2012). Amsterdam's mobility model demonstrates how sustainability

can become a strategic factor in urban development, producing not only environmental benefits but also economic and social advantages.

- **Oslo: Zero-Emission Zones and Traffic Reduction**

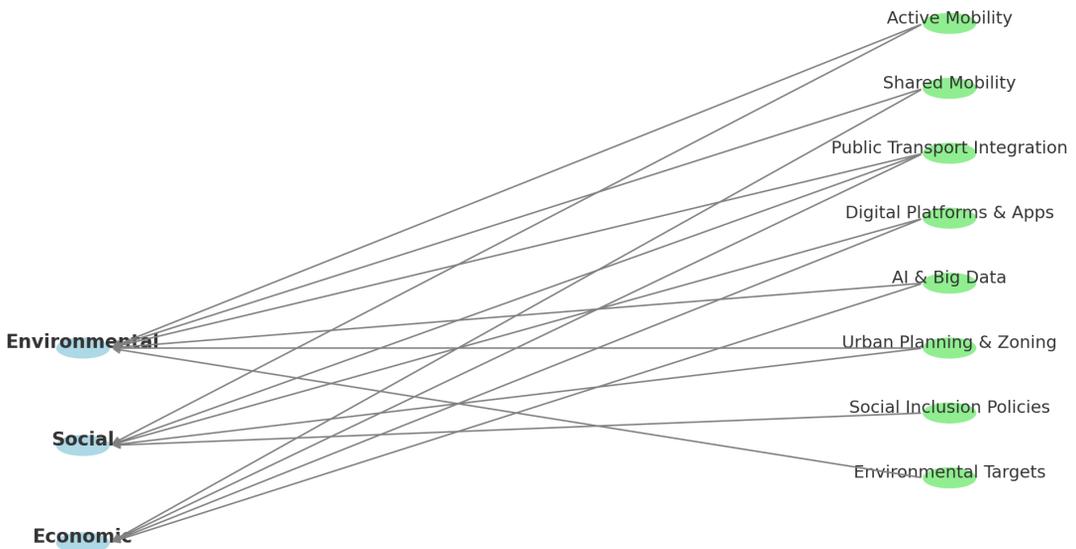
Oslo was one of the first capitals in the world to phase out fossil fuel-powered cars from its city centre. Thanks to incentives for electric vehicles, restrictions on polluting vehicles and the expansion of public transport networks, the city has significantly reduced CO₂ emissions, becoming a model for low-emission urban development (Itoh, 2022). However, the main challenge remains balancing traffic restrictions with maintaining the economic vitality of the city centre. According to Beck, the transition to a low-emission urban model can be seen as a response to new forms of global risk, such as climate change and air pollution (Beck, 1992). Oslo has taken proactive measures to turn these challenges into opportunities, demonstrating that sustainable mobility policy can improve the quality of urban life. From the perspective of urban space production, Lefebvre suggests that reorganising the city through car reduction can redefine the relationship between citizens and the urban environment (Lefebvre, 1991). Pedestrianisation and the expansion of public transport increase the usability of public spaces, strengthening the sense of belonging and participation in the city. Putnam also points out that reducing dependence on private cars can encourage new forms of social interaction, fostering stronger social capital (Putnam, 2000). The transformation of Oslo demonstrates how a holistic approach to mobility can not only reduce environmental impact but also improve the social fabric of the city.

- **Tokyo: High-Tech Public Transportation**

Tokyo is a world leader in public transport efficiency, thanks to its ultra-efficient rail and metro network, which guarantees a punctual and widespread service. The integrated digital payment system and high-speed Shinkansen trains are a benchmark for many cities. Emerging technologies, such as automated trains and Mobility as a Service solutions (Hensher, Mulley, Ho, Wong, Smith & Nelson, 2020), are further improving the sustainability of urban mobility (Bourdieu, 1980). However, population growth and commuter traffic intensity remain constant challenges for the system's capacity and resilience. According to Castells, contemporary cities are increasingly defined by information and communication networks (Castells, 1996). Tokyo's transport system is an example of how the integration of technology and infrastructure can improve the quality of urban life by optimising mobility flows and reducing CO₂ emissions. Lefebvre's theory of social space emphasises that public transport is not only an infrastructural issue but also a social one (Lefebvre, 1991). The digitisation and efficiency of Tokyo's network allow for greater accessibility to urban spaces, reducing mobility inequalities and improving social inclusion. From the perspective of reflexive modernisation, Beck suggests that urban societies must continually adapt to emerging

risks (Beck, 1992). Tokyo addresses the challenges of urbanisation and high population density through advanced technological solutions, demonstrating that innovation can be a key driver of urban sustainability and resilience. Finally, Sassen's perspective on global cities suggests that the efficiency of public transport is a crucial factor in maintaining economic competitiveness and attracting talent (Sassen, 2012). Tokyo's model demonstrates that an advanced mobility system not only reduces emissions and improves liveability, but is also a strategic factor for the city's economic growth.

Integrated Strategies for Sustainable Mobility in Smart Cities



Digitalization and Social Inclusion: A Three-Part Theoretical Perspective

Sustainable mobility is now one of the fundamental pillars of urban transformation, acting as a cornerstone for the construction of smart, inclusive and resilient cities. Contemporary cities face a double challenge: on the one hand, the need to drastically reduce CO₂ emissions and the environmental impact of vehicle traffic; on the other, the need to ensure social equity in access to mobility, preventing technological innovations from becoming new tools of exclusion. In this context, digitalisation offers unprecedented opportunities to improve the efficiency and accessibility of transport systems, but also raises crucial questions in terms of governance, public trust and social justice. As Castells (1996) points out, cities in the information age are structured around flows of people, capital and data: this means that mobility can no longer be understood solely as physical movement, but as an interconnected process that directly affects social dynamics and economic opportunities. The digitisation of transport, thanks to technologies such as GPS, mobile apps, the Internet of

Things (IoT) and artificial intelligence, has transformed the way citizens relate to the urban environment, enabling real-time, personalised and flexible mobility (Jittrapirom et al., 2020). However, as highlighted by van Dijk (2005), differential access to technology can generate new forms of exclusion, penalising those who do not have the digital skills or economic means to benefit from these innovations. This digital divide risks accentuating spatial and social inequalities, excluding the most vulnerable citizens from the benefits of smart mobility. The issue is not merely technical, but deeply political, as suggested by Bourdieu (1986) in his theory of social capital: the networks of relationships and symbolic resources available to individuals influence their ability to navigate the urban system and access its essential services, including those related to mobility. In this sense, mobility is a mirror of social and territorial inequalities. In many cities, peripheral areas suffer from a chronic lack of public transport services, while urban centres tend to concentrate digital infrastructure and higher value-added services (Lefebvre, 1991). This phenomenon not only limits the freedom of movement of suburban residents, but also compromises their ability to participate fully in the economic, educational and cultural life of the city. To counteract these dynamics, it is necessary to adopt a spatial justice perspective that integrates urban planning with social inclusion policies. According to Young (1990), a democratic society must guarantee equal access to common goods, including mobility. This implies not only the design of accessible infrastructure, but also the promotion of participatory models of governance, in which local communities can actively contribute to the definition of mobility policies. Social inclusion is therefore an essential dimension of sustainable mobility. Shared mobility solutions – such as bike sharing, car sharing and integrated public transport services – not only reduce congestion and emissions, but also strengthen community ties and promote more active citizenship (Putnam, 2000). However, for these solutions to be truly effective, they must be designed according to criteria of equity and universal accessibility. Coleman (1990) highlighted the crucial role of social trust in the success of public policies: if citizens perceive that mobility services are designed to favour only certain groups – for example, young people, the wealthy or technophiles – the legitimacy of the system is compromised, resulting in resistance to change and low rates of innovation adoption. To address these challenges, public authorities must adopt an integrated and multi-level approach. Urban mobility governance cannot be entrusted solely to municipalities or transport operators, but must involve the entire urban ecosystem, including citizens, businesses, NGOs and academic institutions. The ‘participatory governance’ model, inspired by Arnstein’s ladder (1969), proposes different levels of citizen involvement, from simple consultation to co-decision. Only through genuine and structured participation is it possible to build mobility policies that truly respond to the needs of the population. Furthermore, the application of Ostrom’s theory of common goods (in Maggi, 2020) suggests that mobility services, when managed as shared resources, can generate greater collective benefits than models based on private ownership. Another important element is the link

between mobility and environmental sustainability. The climate crisis requires a radical transformation of transport systems, moving them towards low-emission and low-land-use models. The European Green Deal and the 2030 Agenda objectives highlight the urgency of reducing transport emissions by 55% by 2030 (European Commission, 2020). In this context, the concept of 'soft mobility' – based on walkability, cycleability and public transport – takes on a strategic role. The 15-minute city model (Moccia, 2024), already adopted in several European capitals, is a concrete example of how urban planning can reduce the need for long journeys while improving the quality of life and inclusiveness of urban space. However, sustainability cannot be understood solely in ecological terms. As Beck (1992) argues, modern societies must adopt a 'reflective modernisation' that takes into account environmental, social and cultural risks. Sustainable mobility must therefore be integrated with a systemic vision of urban change, capable of anticipating crises and transforming infrastructure into platforms for resilience and innovation. In this context, smart cities offer an ideal laboratory for experimenting with advanced technological solutions – such as artificial intelligence, blockchain or autonomous vehicles – provided that these are geared towards the common good and not exclusively towards profit (Moreno et al., 2021). The experiences of Tallinn and Luxembourg, which have introduced free public transport, show that it is possible to significantly increase the use of public transport through universal access policies, provided they are accompanied by structural investments and effective governance (De Gennaro, Paffumi, Martini, Giallonardo, Pedroso & Loiselle-Lapointe 2020). Similarly, cities such as Barcelona, Oslo and Singapore offer different but complementary models of sustainable mobility, based respectively on pedestrian planning, the promotion of electric mobility and digital optimisation. These cases confirm that there is no single model of smart mobility, but a variety of approaches that can be adapted to local and cultural specificities (Maggi, 2020; Shaw & Docherty, 2014). Finally, to ensure that urban mobility is truly a tool for equitable and sustainable development, it must be recognised as a right and a common good. Habermas (1981) conceives of public space as a place of democratic interaction: extending this vision to mobility, we can imagine the transport system as a relational infrastructure, in which circulation is not only about people and goods, but also about ideas, identities and collective aspirations. Guaranteeing universal access to mobility ultimately means guaranteeing the right to the city, understood as active participation in urban life in all its forms. For this reason, it is essential to accompany technological transformations with a strong educational and cultural commitment capable of promoting more sustainable, collaborative and conscious lifestyles.

Conclusions

The conclusions of this study confirm that sustainable mobility is a fundamental pillar for the development of smart cities of the future. Not only does it represent an effective response to global environmental challenges, but it is also an essential

tool for improving the quality of urban life, promoting social inclusion and ensuring a more equitable use of urban resources (Banister, 2008; Geels et al., 2017). The adoption of integrated strategies based on technological innovation and sustainability-oriented urban planning has proven capable of producing tangible benefits in various urban contexts, as demonstrated by the cases of Barcelona, Singapore and Oslo.

In particular, Barcelona's 'superblock' model has highlighted how an approach focused on pedestrianisation and reducing car traffic can significantly improve urban liveability, contributing to lower CO₂ emissions, less noise pollution and the creation of new public spaces (Mueller et al., 2020). At the same time, Singapore's experience highlights the potential of advanced digital infrastructure in intelligent traffic management and public transport optimisation through surveillance technologies, machine learning and dynamic pricing (Phang, 2019). Oslo, with its ambitious plan to electrify its vehicle fleet and eliminate private car traffic from the city centre, also demonstrates how regulatory frameworks can act as catalysts for the ecological transition of urban mobility (De Gennaro, Paffumi, Martini, Giallonardo, Pedroso & Loiseau-Lapointe, 2020).

However, the implementation of sustainable mobility models is hampered by persistent challenges, such as digital inequalities, cultural resistance to change, institutional fragmentation and the complexity of urban governance (Marsden & Reardon, 2017). To effectively address these obstacles, public policies must be accompanied by inclusive and participatory urban planning that considers the diverse needs of the population and promotes equity in access to mobility services. As Lefebvre (1991) pointed out, urban space is not neutral, but the product of power relations and political decisions: sustainable mobility, therefore, cannot be limited to technical objectives, but must be part of a broader strategy of spatial justice.

Comparative analysis of urban models has highlighted different approaches to sustainable mobility, reflecting local priorities, governance styles and the cultural specificities of different contexts. For example, some cities focus on redesigning urban space and promoting soft mobility (such as Paris with its '15-minute city'), others invest in digital infrastructure and intelligent systems (such as Singapore), while others use fiscal and regulatory instruments to encourage virtuous behaviour (Maggi, 2020). The classification of these models allows for greater transferability of good practices and promotes learning between cities, facilitating the adoption of solutions that have already been tested in similar contexts (Joss et al., 2017).

Looking ahead, the integration of new technologies, such as artificial intelligence, blockchain and Internet of Things (IoT) systems, with sustainable urban planning models, such as the aforementioned '15-minute city', could revolutionise the way people move and interact with urban space (Moreno et al., 2021). These technologies enable more efficient resource management, data-driven planning and greater

personalisation of mobility services. However, to ensure that these tools do not become new sources of exclusion, it is essential to adopt an approach that is attentive to social inclusion, guaranteeing universal access to the benefits of innovation.

According to Castells (1996), the contemporary city is a 'space of flows', in which transport, communication and information networks play a crucial role in defining opportunities for economic and social participation. In this context, strengthening public transport, promoting active mobility and reducing dependence on private cars are essential strategies for ensuring equitable access to urban resources. Furthermore, as suggested by Putnam's social capital theory (2000), the quality of mobility affects social cohesion: accessible and inclusive transport systems strengthen community ties, increase mutual trust and promote integration.

Another crucial aspect is governance. An effective urban mobility governance model must be participatory, flexible and oriented towards continuous learning. Ostrom (1990) demonstrated how participatory management of common resources can ensure more efficient and sustainable use of shared infrastructure. In this sense, shared mobility (car sharing, bike sharing, etc.) is an emblematic example of the application of collaborative governance principles. Lefebvre (1991) also argues that only a city that guarantees the 'right to mobility' can be considered truly fair and sustainable.

Finally, the transition to Industry 5.0, with its focus on the interaction between humans and technology, opens up new possibilities for rethinking mobility as an adaptive public service oriented towards collective well-being (European Commission, 2021). Smart communities can serve as testing grounds for innovative solutions, but the success of these experiments will depend on the ability of policymakers to integrate technological innovation with inclusive policies, preventing digital inequalities from translating into new forms of exclusion (Sheller, 2018).

Ultimately, only through a holistic and collaborative approach that combines innovation, participation and social justice will it be possible to transform urban mobility into a real driver of equitable, resilient and sustainable development. Mobility in smart cities must be seen not only as a means of getting around, but as a social right, a lever for ecological transformation and a tool for cohesion. The experience of the cities analysed shows that change is possible, but it requires vision, political courage and, above all, democratic governance capable of including everyone's voices.

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